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(54) **SYSTEM AND DESIGN OF COST EFFECTIVE CHASSIS DESIGN FOR NETWORKING PRODUCTS**

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(51) **Int. Cl.**

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G06F 1/20	(2006.01)
H05K 7/14	(2006.01)
H01L 23/473	(2006.01)

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CPC ***H05K 7/20736*** (2013.01); ***G06F 1/20*** (2013.01); ***H05K 7/1488*** (2013.01); ***H05K 7/1492*** (2013.01)

(58) **Field of Classification Search**
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USPC 361/756, 741, 686, 687, 725, 787, 789, 361/794, 807–810, 676–678, 361/679.46–679.54, 688–723; 348/787, 348/789, 794; 349/56–60; 165/80.1–80.5, 165/104.33, 185; 174/15.1–15.3, 174/16.1–16.3, 547, 548; 257/712–722, 257/E23.088; 24/453, 458–459; 454/184; 312/236
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,151,210 A *	11/2000	Cercioglu	H05K 7/20572	165/104.33
6,198,630 B1 *	3/2001	Cromwell	H01L 23/4006	165/80.3
6,449,150 B1 *	9/2002	Boone	H05K 7/20563	165/104.33
6,563,706 B1 *	5/2003	Strickler	H05K 7/20718	165/122
6,785,142 B1	8/2004	Regimbal et al.		

(Continued)

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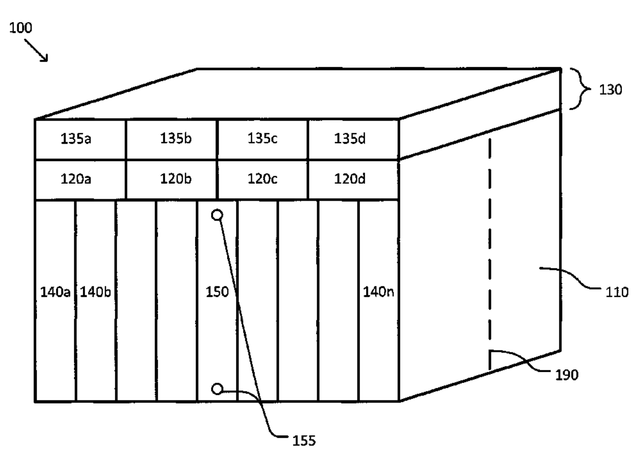
(57) **ABSTRACT**

An electrical equipment chassis includes a frame open to a first side and an opposite second side and a power board located near a mid-plane of the chassis coupling power supply modules to first networking modules and a second networking module. A first region open to the first side can receive first power supply modules. A second region open to the first side is adjacent to the first region and can receive the first networking modules and the second networking module oriented with a first orientation. A third region open to the second side can receive fan trays with fans and third networking modules. The third networking modules are oriented orthogonal to the first orientation. The power board at least partially separates the first and third regions and only partially separates the second and third regions. The chassis permits air flow from the first side to the second side.

20 Claims, 7 Drawing Sheets

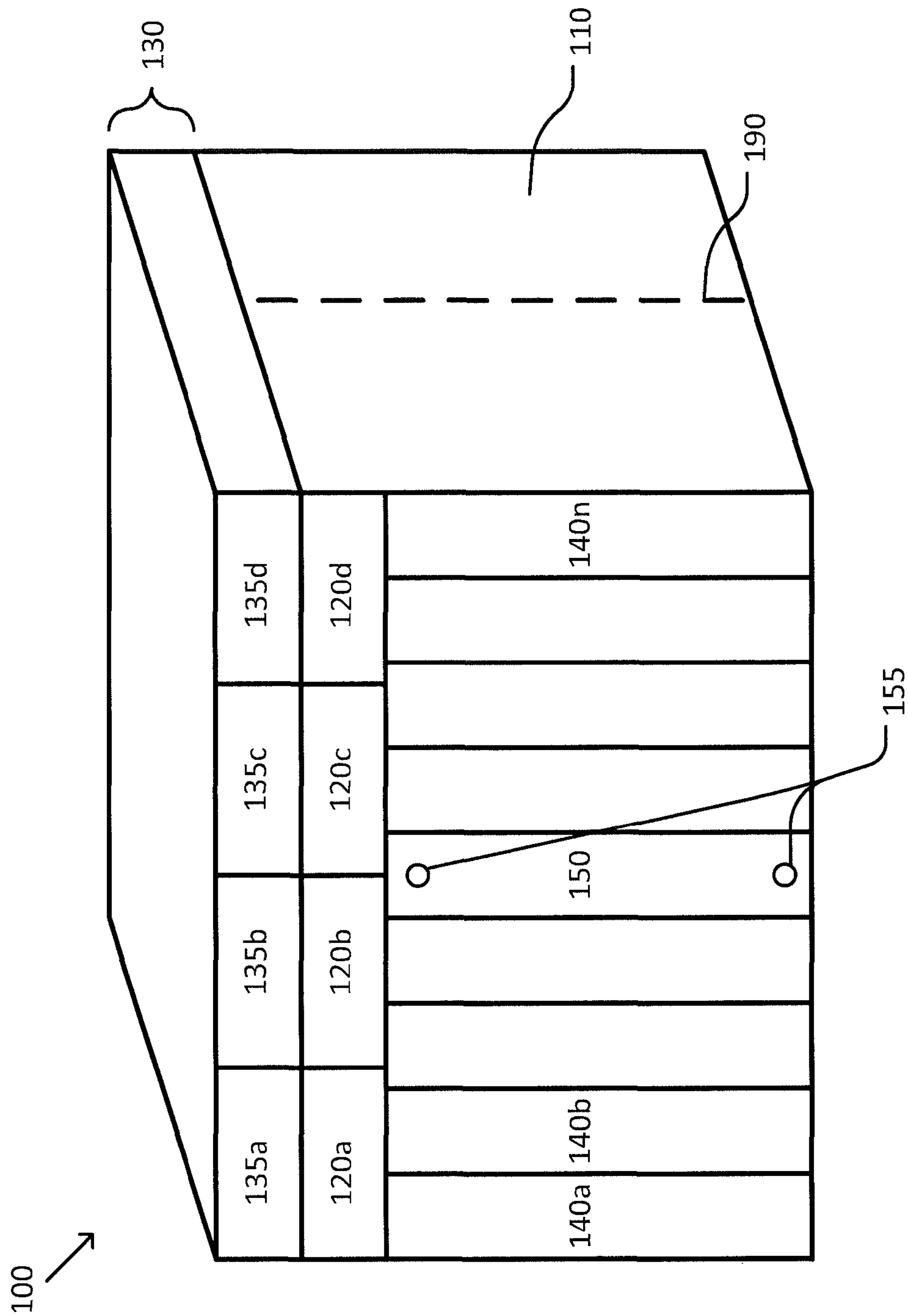


(56) **References Cited**

U.S. PATENT DOCUMENTS

7,088,583 B2 8/2006 Brandon et al.
8,064,200 B1 11/2011 West et al.
8,792,243 B2 7/2014 Babcock et al.
2003/0214781 A1* 11/2003 Kolb G06F 1/206 361/679.33
2003/0221817 A1 12/2003 Smith et al.
2004/0001311 A1* 1/2004 Doblar G06F 1/20 361/679.49
2004/0008484 A1* 1/2004 Konshak G06F 1/184 361/679.5
2004/0150950 A1 8/2004 Brooks et al.
2004/0228090 A1* 11/2004 Blackwell H05K 7/1457 361/695
2005/0207134 A1* 9/2005 Belady H05K 1/14 361/796
2005/0276017 A1 12/2005 Aziz et al.
2006/0227505 A1 10/2006 Miyamoto et al.
2006/0256522 A1 11/2006 Wei et al.
2007/0013061 A1* 1/2007 Chen H05K 1/0274 257/728
2007/0178822 A1 8/2007 Lanus et al.
2007/0213000 A1* 9/2007 Day H05K 7/20745 454/184
2007/0232089 A1* 10/2007 Fung H05K 1/14 439/65
2007/0274039 A1* 11/2007 Hamlin H05K 7/2019 361/695
2008/0043427 A1* 2/2008 Lee G06F 1/1601 361/679.48
2008/0112133 A1* 5/2008 Torudbakken H04Q 1/04 361/694
2008/0180918 A1 7/2008 Baker et al.
2008/0192431 A1* 8/2008 Bechtolsheim H05K 7/20727 361/695
2008/0310121 A1* 12/2008 Yamashita H01R 9/226 361/720
2009/0016019 A1* 1/2009 Bandholz H05K 7/20736 361/695
2009/0086422 A1* 4/2009 McClure H05K 7/20772 361/679.48
2009/0097203 A1* 4/2009 Byers H05K 7/20618 361/695
2009/0109610 A1* 4/2009 Hirai G06F 1/20 361/679.46
2009/0109619 A1* 4/2009 Wise H05K 7/20836 361/695
2009/0135558 A1* 5/2009 Hughes H05K 7/20727 361/679.46
2009/0260795 A1* 10/2009 Perazzo H05K 7/20572 165/269
2009/0296352 A1 12/2009 Lima
2010/0002382 A1* 1/2010 Aybay H05K 7/20563 361/695
2010/0014248 A1* 1/2010 Boyden H05K 7/20563 361/695
2010/0315771 A1 12/2010 Wu et al.
2011/0080701 A1* 4/2011 Bisson H05K 7/20563 361/679.5
2011/0188220 A1* 8/2011 Blackwell, Jr. H05K 1/11 361/802
2011/0192587 A1 8/2011 Lima
2011/0194245 A1* 8/2011 Wu G06F 1/184 361/679.48
2011/0222241 A1* 9/2011 Shearman H05K 7/20572 361/692

* cited by examiner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110
190
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FIG. 1

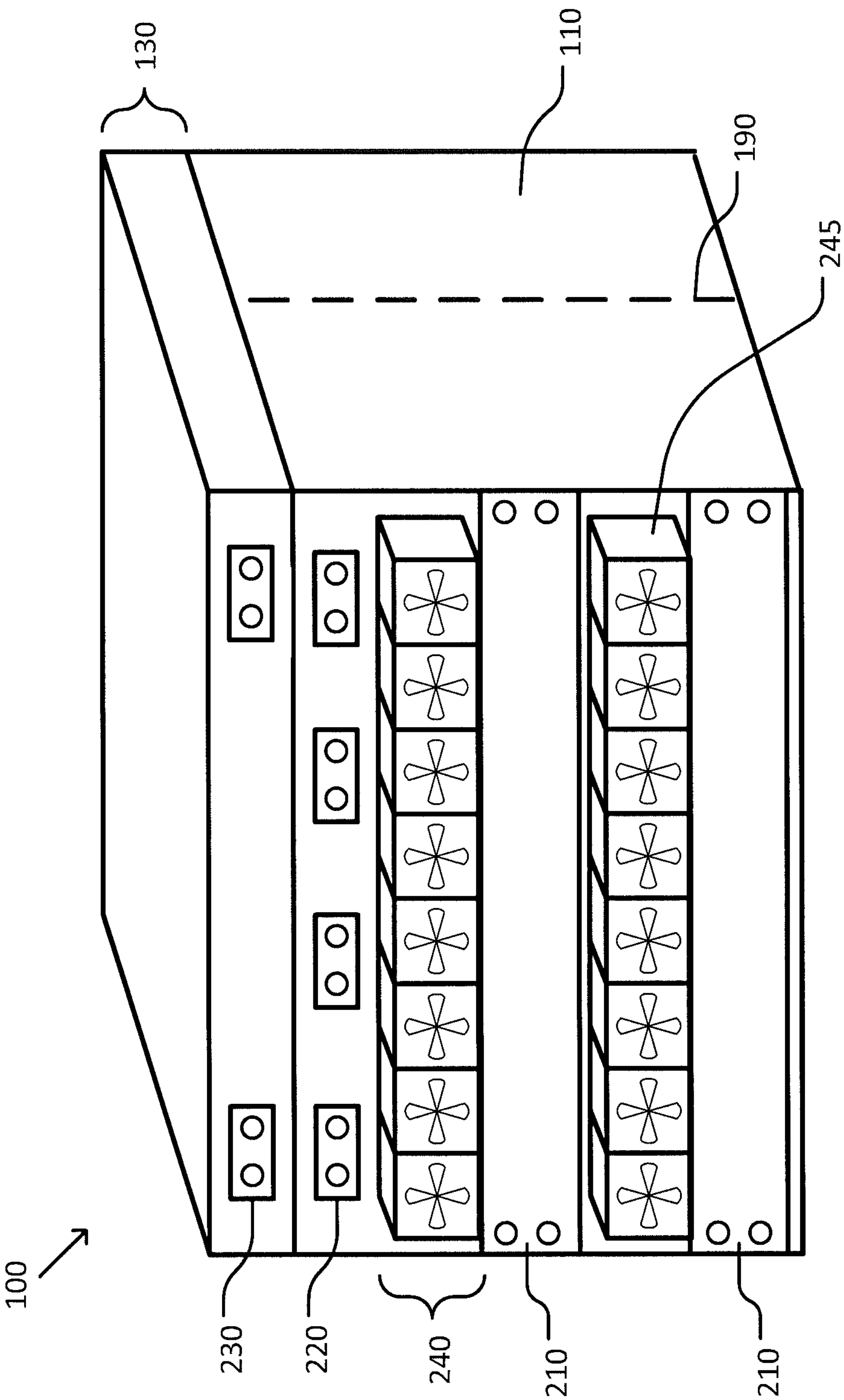
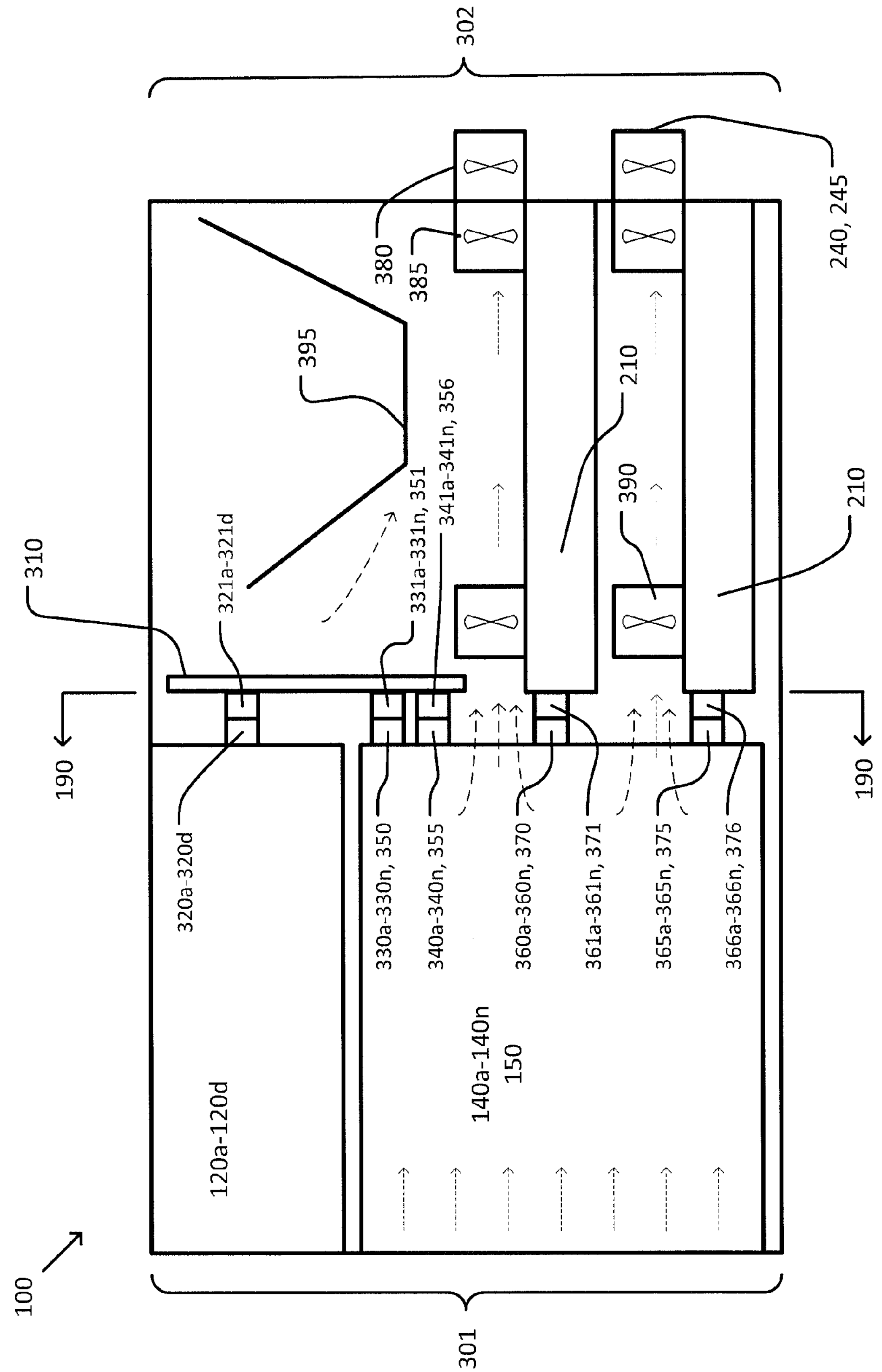


FIG. 2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240, 245
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340a-340n, 355
360a-360n, 370
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140a-140n
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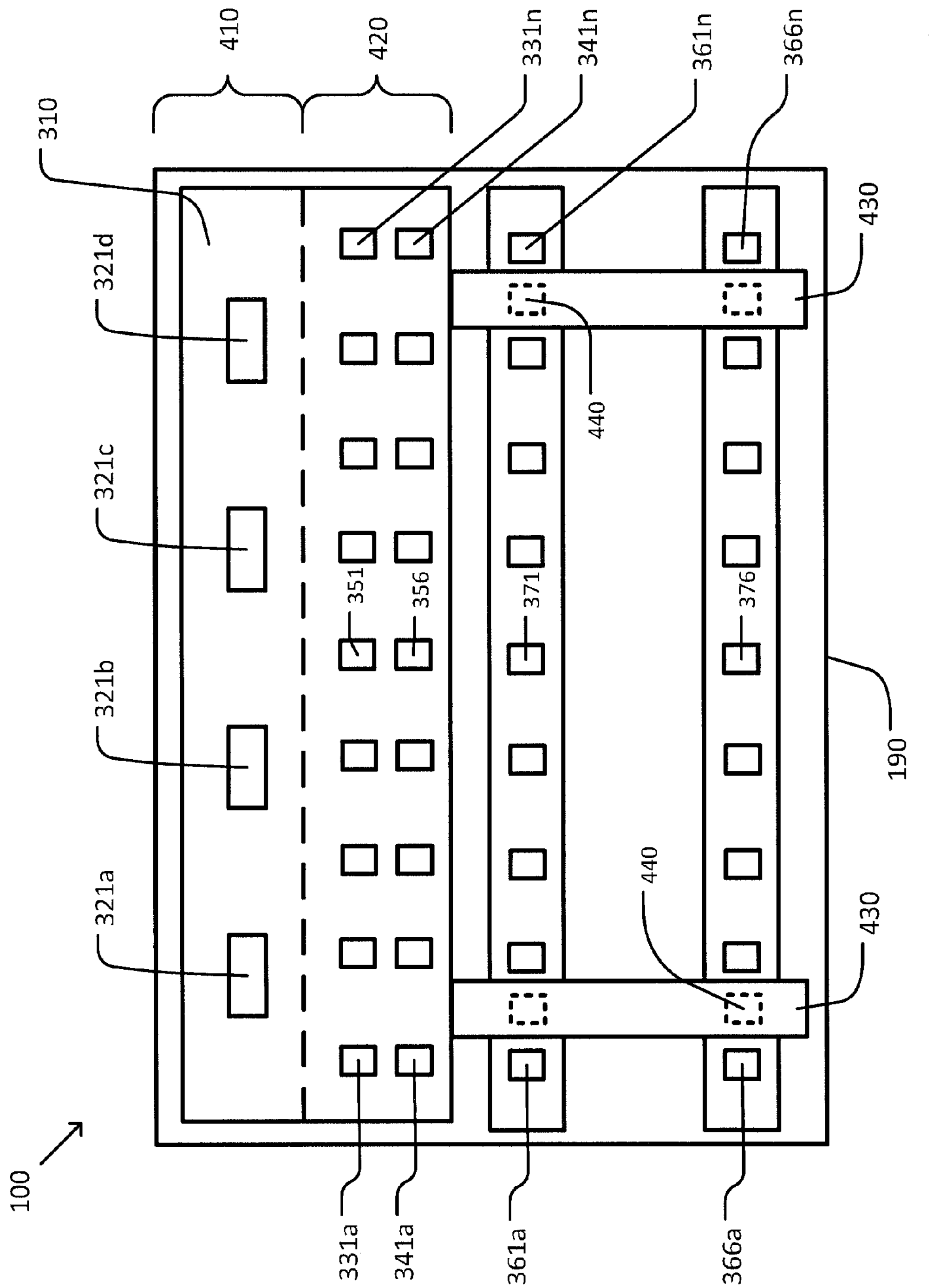
120a-120d
100
301

FIG. 3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366n
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341a
361a
366a

FIG. 4

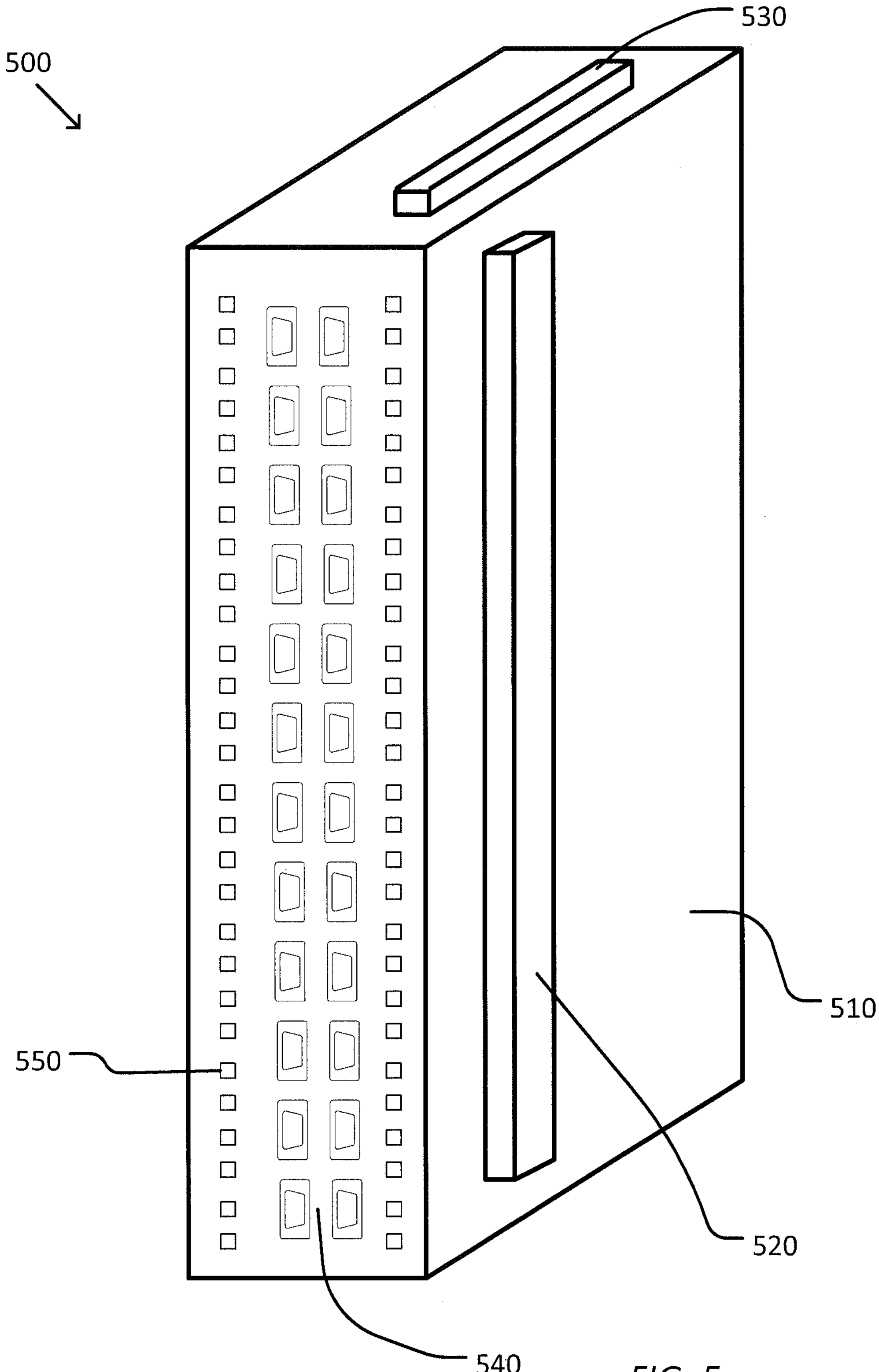

FIG. 5

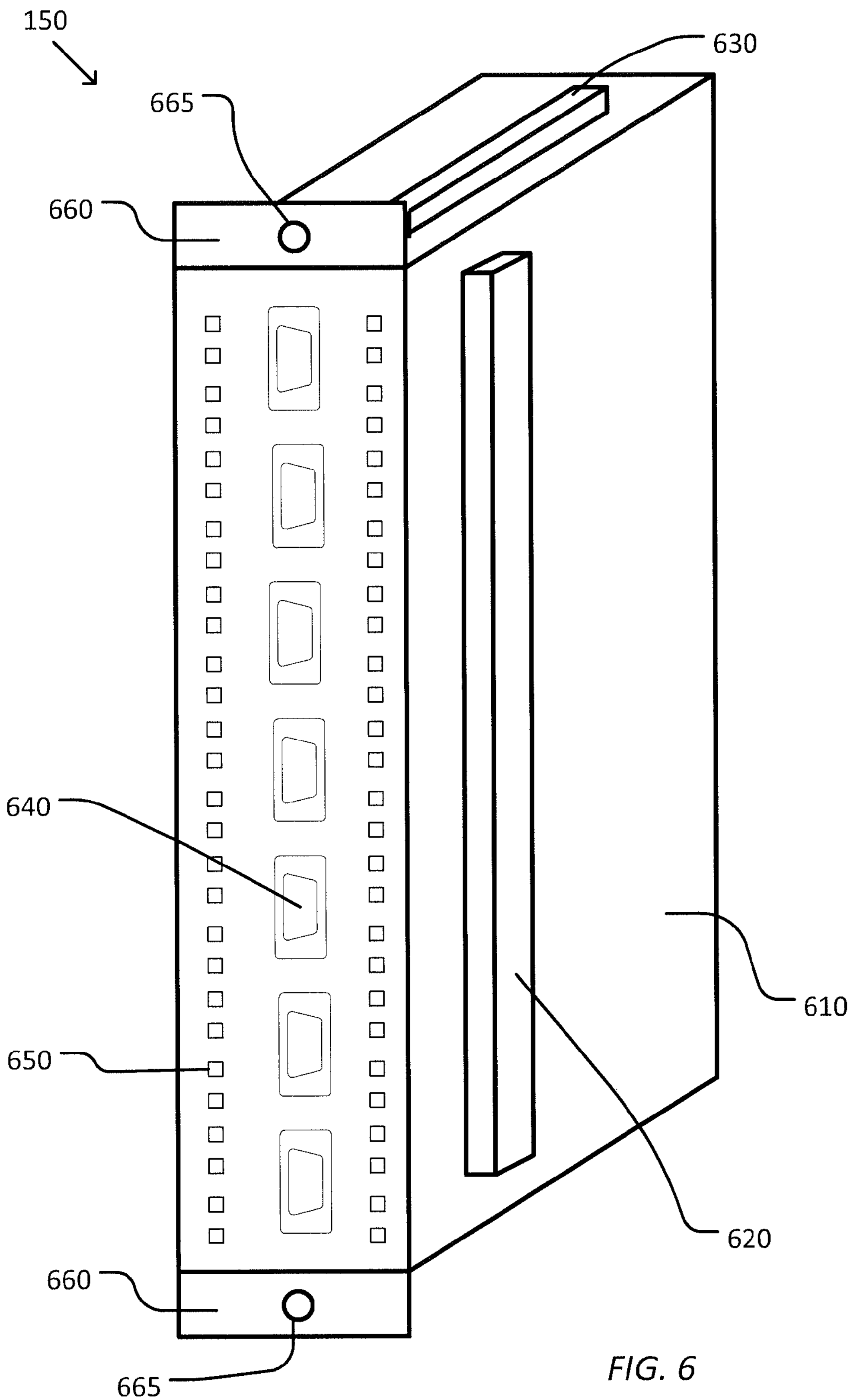

FIG. 6

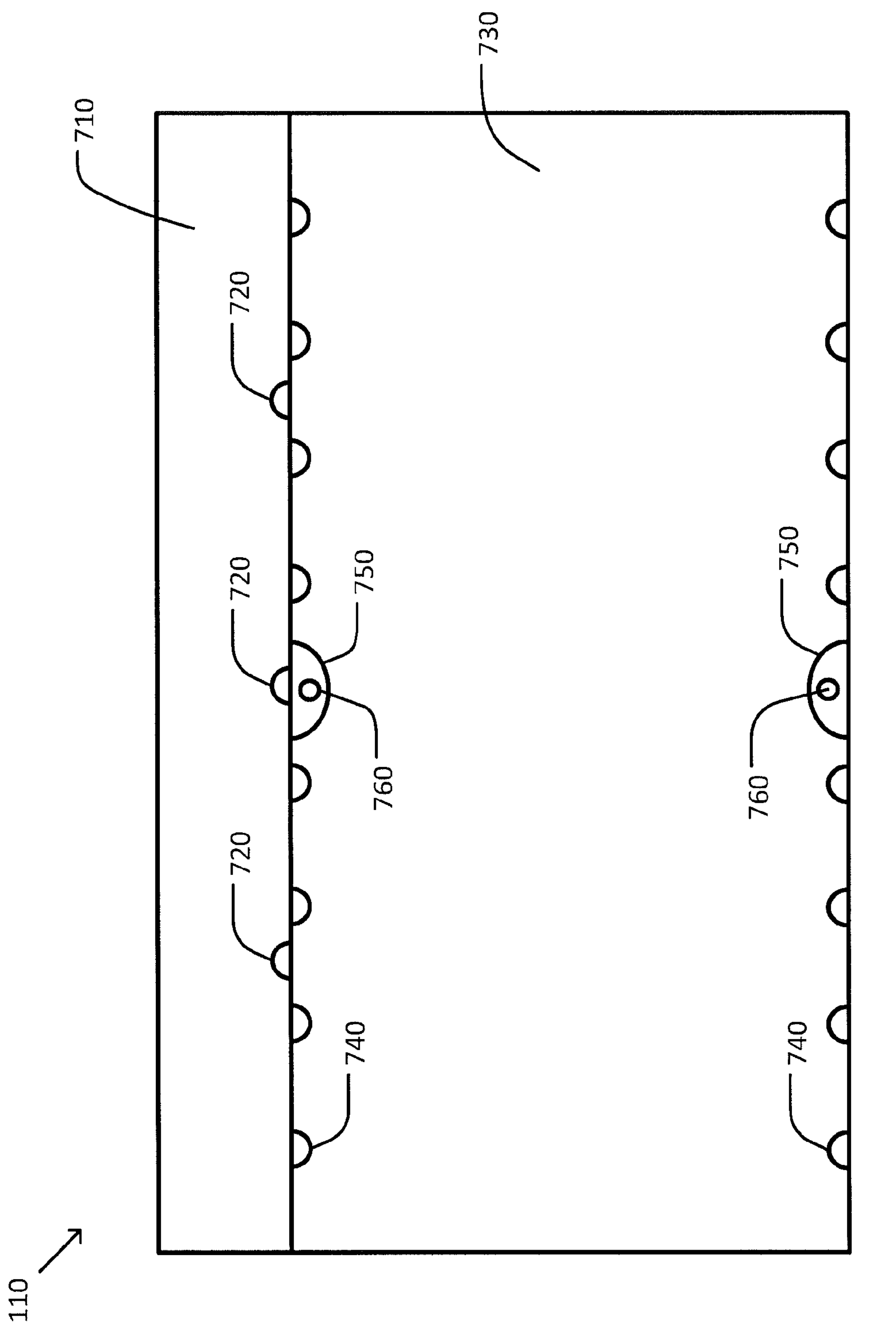

FIG. 7

SYSTEM AND DESIGN OF COST EFFECTIVE CHASSIS DESIGN FOR NETWORKING PRODUCTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. Patent Application No. 13/674,879, filed Nov. 12, 2012, which is hereby incorporated by reference in its entirety.

BACKGROUND

The present disclosure relates generally to information handling systems, and more particularly to a chassis design relating to network switching products. But it would be recognized that the invention has a much broader range of applicability.

As the value and use of information continues to increase, individuals and businesses seek additional ways to process and store information. One option is an information handling system (IHS). An IHS generally processes, compiles, stores, and/or communicates information or data for business, personal, or other purposes. Because technology and information handling needs and requirements may vary between different applications, IHSs may also vary regarding what information is handled, how the information is handled, how much information is processed, stored, or communicated, and how quickly and efficiently the information may be processed, stored, or communicated. The variations in IHSs allow for IHSs to be general or configured for a specific user or specific use such as financial transaction processing, airline reservations, enterprise data storage, or global communications. In addition, IHSs may include a variety of hardware and software components that may be configured to process, store, and communicate information and may include one or more computer systems, data storage systems, and networking systems.

With the advent of centralized locations for storing data associated with network services (retail services, financial services, communication/social networking services, database services to name only a few), network devices such as switches and routers are designed to very quickly process and route large volumes of network traffic. Such centralized locations are typically referred to as data centers.

Network switching products form the interconnection backbone in data centers. In order to support large numbers of network switching products, these network switching products are often designed around standard form factors and sizes. Typically these form factors and sizes are designed so that the network switching products can be rack mounted using interchangeable slots. A common feature in the rack-mounted arrangement is a chassis. A typical chassis includes a rigid frame with one or more power supplies and one or more interchangeable slots for receiving a corresponding one or more network switching products. Chassis have been typically designed to provide both flexibility and redundancy in network configuration and operation. By using interchangeable slots, the number and variety of network switching products that are installed is flexible. Not only does this provide the ability to swap out defective network switching products and to upgrade previously installed network switching products, it also provides for the ability to add additional network switching products to previously installed chassis, subject to space availability. In addition, with the advent of hot-swappable network switching products, it is possible to replace a network switching product while the other network switching products in the system remain active and functioning.

One common type of chassis includes a backplane. The backplane is typically a fixed interconnection unit that provides connectivity and routing between the various network switching line cards are inserted into the slots of the chassis. For example, the backplane includes a circuit board with various card edge connectors into which each of the network switching products are inserted. The circuit board generally contains an extensive bus and point-to-point wiring pattern that interconnects pins between the card edge connectors that allow each of the network switching products to communicate. In another example, the circuit board includes power supply wiring for supplying power to each of the network switching line cards. The use of a backplane places certain limits on the capabilities of the chassis to support additional and upgraded network switching products. For example, one such limit is the number of slots (i.e., card edge connectors) provided by the backplane, this is typically fixed in number and provides a finite upper limit on the number of network switching capability the chassis supports. The design of card edge connectors and the backplane circuit board can place additional limits on upgradability due to limitations associated with signal integrity, frequency limits, and the like. Further, the use of a monolithic backplane may interfere significantly with cooling airflow between the front and back of the chassis. Not only does the backplane design impose a high infrastructure cost, but the limitations typically limit the effective life span of the backplane-based chassis.

More recently, chassis design has begun to migrate away from the backplane design to a mid-plane design. In a mid-plane design, the interconnect circuit board is moved from the back of the chassis to near the center of the chassis. For example, network switching products in the form of line cards are inserted from the front of the chassis into card edge, or similar, connectors on the front surface of the mid-plane interconnect circuit board. Additional network switching cards in the form of route processor modules (RPMS) or fabric cards are inserted from the rear of the chassis into card edge, or similar, connectors on the rear surface of the mid-plane interconnect circuit board. In some examples, the interconnect model is orthogonal in nature such that the line cards are inserted into the mid-plane interconnect circuit board in a first orientation (e.g., vertical) and the RPMs are inserted into the mid-plane interconnect circuit board in a second orientation that is orthogonal to the first orientation (e.g., horizontal). As in the case of the backplane chassis, the presence of the mid-plane interconnect circuit board in the mid-plane chassis places the same limits on the chassis related to slot capacity, electrical signal characteristics, and interference with cooling airflow between the front and back of the chassis.

Accordingly, it would be desirable to provide an improved chassis design that provides greater flexibility in slot capacity, increased longevity due to ability to adapt to ever increasing electrical signal characteristics, and/or better support for cooling airflow through the chassis.

SUMMARY

According to one embodiment, an electrical equipment chassis includes a frame open to a first side of the chassis and a second side of the chassis opposite the first side, the frame separating the chassis into a first region, a second region, and a third region and a power distribution board located near a mid-plane of the chassis and including one or more power

module connectors for coupling one or more first power supply modules to the power distribution board and one or more first power connectors for coupling one or more first networking modules and a second networking module to the power distribution board. The first region is open to the first side of the chassis and is configured to receive the one or more first power supply modules for supplying power to the chassis. The second region is open to the first side of the chassis, is adjacent to the first region, and is configured to receive the one or more first networking modules and the second networking module. The one or more first networking modules and the second networking module are oriented with a first orientation. The third region is open to the second side of the chassis and is configured to receive one or more fan trays and one or more third networking modules. The one or more third networking modules are oriented with a second orientation orthogonal to the first orientation. The one or more fan trays each includes one or more fans. The power distribution board at least partially separates the first region from the third region and only partially separates the second region from the third region. At least one of the second networking module, the one or more fan trays, or the one or more third networking modules adds stability to the frame. The chassis is sufficiently open to permit air flow from the first side to the second side.

According to another embodiment, an information handling system includes one or more electrical equipment chassis. Each of the electrical equipment chassis includes a frame open to a first side of the chassis and a second side of the chassis opposite the first side, the frame separating the chassis into a first region, a second region, and a third region and a power distribution board located near a mid-plane of the chassis and including one or more power module connectors for coupling the one or more first power supply modules to the power distribution board and one or more first power connectors for coupling one or more first networking modules and a second networking module to the power distribution board. The first region is open to the first side of the chassis and is configured to receive the one or more first power supply modules for supplying power to the chassis. The second region is open to the first side of the chassis, is adjacent to the first region, and is configured to receive the one or more first networking modules and the second networking module. The one or more first networking modules and the second networking module are oriented with a first orientation. The third region is open to the second side of the chassis and is configured to receive one or more fan trays and one or more third networking modules. The one or more third networking modules are oriented with a second orientation orthogonal to the first orientation. The one or more fan trays each includes one or more fans. The power distribution board at least partially separates the first region from the third region and only partially separates the second region from the third region. At least one of the second networking module, the one or more fan trays, or the one or more third networking modules adds stability to the frame. The chassis is sufficiently open to permit air flow from the first side to the second side.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a simplified front view diagram of an example of a chassis according to some embodiments of the present invention.

FIG. **2** shows a simplified rear view diagram of the chassis according to some embodiments of the present invention.

FIG. **3** shows a simplified cut-away side-view diagram of the chassis according to some embodiments of the present invention.

FIG. **4** shows a simplified frontal diagram of the midplane of the chassis according to some embodiments of the present invention.

FIG. **5** shows a simplified diagram of a first networking module according to some embodiments of the present invention.

FIG. **6** shows a simplified diagram of the second networking module according to some embodiments of the present invention.

FIG. **7** shows a simplified front view diagram of the frame according to some embodiments of the present invention.

In the figures, elements having the same designations have the same or similar functions.

DETAILED DESCRIPTION

In the following description, specific details are set forth describing some embodiments of the present invention. It will be apparent, however, to one skilled in the art that some embodiments may be practiced without some or all of these specific details. The specific embodiments disclosed herein are meant to be illustrative but not limiting. One skilled in the art may realize other elements that, although not specifically described here, are within the scope and the spirit of this disclosure. In addition, to avoid unnecessary repetition, one or more features shown and described in association with one embodiment may be incorporated into other embodiments unless specifically described otherwise or if the one or more features would make an embodiment non-functional.

For purposes of this disclosure, an IHS may include any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, entertainment, or other purposes. For example, an IHS may be a personal computer, a PDA, a consumer electronic device, a display device or monitor, a network server or storage device, a switch router or other network communication device, or any other suitable device and may vary in size, shape, performance, functionality, and price. The IHS may include memory, one or more processing resources such as a central processing unit (CPU) or hardware or software control logic. Additional components of the IHS may include one or more storage devices, one or more communications ports for communicating with external devices as well as various input and output (I/O) devices, such as a keyboard, a mouse, and a video display. The IHS may also include one or more buses operable to transmit communications between the various hardware components.

FIG. **1** shows a simplified front view diagram of an example of a chassis **100** according to some embodiments of the present invention. As shown in FIG. **1**, the chassis **100** is configured around a box like frame **110**, sometimes called the hem. The frame **110** is configured to receive various types of modules depending upon the desired configuration and function of the modules inserted into the chassis **100**. The frame **110** will be described further below. The chassis further includes a virtual mid-plane **190** where interconnections can be made between various modules as will be described further below.

As further shown in FIG. **1**, the chassis **100** can be configured to receive one or more first power supply modules **120***a*-**120***d*. For example, four first power supply modules **120***a*-**120***d* are depicted, but one of ordinary skill in the art would recognize that fewer or more power supply modules can be used. Each of the one or more power supply modules **120***a*-**120***d* are configured to supply one or more voltage levels and power to the other modules inserted into the chassis **100**. For example, the one or more power supply modules **120***a*-**120***d* can supply 12 VDC, 54 VDC, and/or any other voltage level necessary to support the functionality of the modules inserted into the chassis **100**. Also shown with the chassis **100** is an optional auxiliary power shelf **130**. The auxiliary power shelf **130** provides the capability to add an additional one or more auxiliary power supply modules **135***a*-**135***d* to the chassis **100**. In some embodiments, the one or more auxiliary power supply modules **135***a*-**135***d* can provide extra power capabilities to the other modules inserted into the chassis **100**. According to some embodiments, the one or more auxiliary power supply modules **135***a*-**135***d* can provide power to additional devices that are connected into the modules. In some embodiments, the one or more auxiliary power supply modules **135***a*-**135***d* can provide 54 VDC to support Power over Ethernet.

FIG. **1** further shows that one or more first networking modules **140***a*-**140***n* can be inserted into chassis **100**. The one or more first networking modules **140***a*-**140***n* can include one or more line card modules and/or one or more service modules. The number of first networking modules **140***a*-**140***n* depends on a width of each of the first networking modules **140***a*-**140***n* and a width of the chassis **100**. The number of first networking modules **140***a*-**140***n* also depends on the number of first networking modules **140***a*-**140***n* to fulfill the networking switching capabilities. It is not required that all of the one or more first networking modules **140***a*-**140***n* be installed in a single chassis **100**, or that chassis **100** be completely filled.

According to some embodiments, a second networking module **150** can be inserted into chassis **100**. For example, the second networking module **150** can be a network uplink module. As shown in FIG. **1**, the second networking module **150** can be affixed to the chassis **100** using one or more fasteners **155**. The one or more fasteners **155** can be configured to affix the second networking module **150** to the frame **110**. For example, the one or more fasteners **155** can be knurled screws. By affixing the second networking module **150** to the frame **110**, the second networking module **150** can be configured to add structural stability to the frame **110**. The second networking module **150** can typically be inserted into the chassis **100** near the horizontal mid-point of the chassis **100**, although second networking module **150** can be inserted in any position on the chassis **100**.

As discussed above and further emphasized here, FIG. **1** is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. According to some embodiments, the modules inserted into the chassis **100** could be inserted with different configurations and orientations. A chassis according to some embodiments may accommodate the one or more power supply modules **120***a*-**120***d* inserted in a vertical orientation. The chassis may accommodate the one or more auxiliary power supply modules **135***a*-**135***d* inserted in a vertical orientation. In some embodiments, the chassis may be configured so that the one or more power supply modules **120***a*-**120***d* and the auxiliary power shelf **130** can be mounted on the bottom of the chassis **100**. In some embodiments, the chassis may accommodate the one or more first networking modules **140***a*-**140***n* inserted in a horizontal orientation. In some embodiments, more than one second networking module **150** may be inserted into the chassis **100**.

FIG. **2** shows a simplified rear view diagram of the chassis **100** according to some embodiments of the present invention. As shown in FIG. **2**, the chassis **100** and the frame **110** are configured to receive one or more third networking modules **210**. In some embodiments, each of the one or more third networking modules includes route processing modules (RPMs). Each of the one or more third networking modules **210** can typically be inserted into the chassis **100** in an orientation that is orthogonal to the one or more first networking modules **140***a*-**140***n* and the second networking module **150**. Each of the one or more third networking modules **210** may optionally be affixed to the rear of the frame **110** using one or more fasteners. The one or more fasteners can be knurled screws. By affixing the one or more third networking modules **210** to the frame **110**, the one or more third networking modules **210** can be configured to add structural stability to the frame **110**.

As additionally shown in FIG. **2**, one or more optional first terminal blocks or connectors **220** can be provided for making external connection to the voltages provided by the one or more first power supply modules **120***a*-**120***d*. Also provided are one or more optional auxiliary terminal blocks or connectors **230** on the rear of the auxiliary power shelf **130** for making external connection to the voltages provided by the one or more auxiliary power supply modules **135***a*-**135***d*.

One or more fan trays **240** can also be mounted to the rear of the chassis **100**. Each of the one or more fan trays **240** includes one or more fan modules **245**. Each of the one or more fan trays **240** can typically be mounted at a height above a corresponding one of the one or more third networking modules **210**. Each of the one or more fan trays **240** can further be configured to provide cooling air flow across the corresponding one or more third networking modules **210** as will be described further below. Each of the one or more fan trays **240** may be mounted so as to extend beyond the back of the chassis **100**. Each of the one or more fan trays **240** may be affixed to the rear of the frame **110** using one or more fasteners. The one or more fasteners can be knurled screws. By affixing the one or more fan trays **240** to the frame **110**, the one or more fan trays **240** can be configured to add structural stability to the frame **110**.

FIG. **3** shows a simplified cut-away side-view diagram of the chassis **100** according to some embodiments of the present invention. As shown in FIG. **3**, the front **301** of the chassis **100** is depicted to the left of the figure and the rear **302** of the chassis **100** is depicted to the right of the figure. The one or more power supply modules **120***a*-**120***d*, as further described with respect to FIG. **1**, can be inserted into the chassis **100** at the top front. Each of the one or more power supply modules **120***a*-**120***d* can include a power supply connector **320***a*-**320***d*, which is typically located at the rear of the corresponding one or more power supply modules **120***a*-**120***d*. Each power supply connector **320***a*-**320***d* can be coupled to a corresponding power module connector **321***a*-**321***d* mounted on a power distribution board **310**. The power distribution board may located at or near the mid-plane **190** of the chassis **100** so that the power distribution board **310** is located nearer to the mid-plane **190** of the chassis than to the front **301** or rear **302** of the chassis. The coupling between the power supply connectors **320***a*-**320***d* and the power module connectors **321***a*-**321***d* can provide power to the power distribution board **310**.

Inserted into the front **301** of the chassis **100** are the various one or more first networking modules **140***a*-**140***n* and second networking module **150**. Each of the one or more first networking modules **140***a*-**140***n* can include a first power distribution connector **330***a*-**330***n*, an optional second power distribution connector **340***a*-**340***n*, a first communication connector **360***a*-**360***n*, and a second communication connector **365***a*-**365***n*, each typically located at the rear of the corresponding one or more first networking modules **140***a*-**140***n*. Each first power distribution connector **330***a*-**330***n* can be coupled to a corresponding third power distribution connector **331***a*-**331***n* mounted on the power distribution board **310**. Each second power distribution connector **340***a*-**340***n* can be coupled to a corresponding fourth power distribution connector **341***a*-**341***n* mounted on the power distribution board **310**. The coupling between the first power distribution connectors **330***a*-**330***n* and the third power distribution connectors **331***a*-**331***n* can provide power to the one or more first networking modules **140***a*-**140***n*. The coupling between the second power distribution connectors **340***a*-**340***n* and the fourth power distribution connectors **341***a*-**341***n* may also provide power to the one or more first networking modules **140***a*-**140***n*. Each first communication connector **360***a*-**360***n* can be coupled to a corresponding third communication connector **361***a*-**361***n*, which can be located at the front of a first one of the third networking modules **210**. The coupling between each of the first communication connectors **360***a*-**360***n* and the corresponding third communication connector **361***a*-**361***n* permits communication and network traffic to pass between the one or more first networking modules **140***a*-**140***n* and the first one of the third networking modules **210**. Each second communication connector **365***a*-**365***n* can be coupled to a corresponding fourth communication connector **366***a*-**366***n*, which can be located at the front of a second one of the third networking modules **210**. The coupling between each of the second communication connectors **365***a*-**365***n* and the corresponding fourth communication connector **366***a*-**366***n* permits communication and network traffic to pass between the one or more first networking modules **140***a*-**140***n* and the second one of the third networking modules **210**.

The second networking module **150** can include a fifth power distribution connector **350**, an optional sixth power distribution connector **355**, a fifth communication connector **370**, and a sixth communication connector **375**, each typically located at the rear of the second networking module **150**. The fifth power distribution connector **350** can be coupled to a corresponding seventh power distribution connector **351** mounted on the power distribution board **310**. The sixth power distribution connector **355** can be coupled to a corresponding eighth power distribution connector **356** mounted on the power distribution board **310**. The coupling between the fifth power distribution connector **350** and the seventh power distribution connector **351** can provide power to the second networking module **150**. The coupling between the sixth power distribution connector **355** and the eighth power distribution connector **356** may also provide power to the second networking module **150**. The fifth communication connector **370** can be coupled to a corresponding seventh communication connector **371**, which can be located at the front of the first one of the third networking modules **210**. The coupling between the fifth communication connector **370** and the seventh communication connector **371** permits communication and network traffic to pass between the second networking module **150** and the first one of the third networking modules **210**. Each sixth communication connector **375** can be coupled to a corresponding eighth communication connector **376**, which can be located at the front of the second one of the third networking modules **210**. The coupling between each of the sixth communication connector **375** and the eighth communication connector **376** permits communication and network traffic to pass between the second networking module **150** and the second one of the third networking modules **210**.

Because communications between the one or more first networking modules **140***a*-**140***n* and the one or more third networking modules **210** as well as the communications between the second networking module **150** and the one or more third networking modules **210** are made locally using connectors (e.g., the connectors **360***a*-**360***n* to **361***a*-**361***n*, **365***a*-**365***n* to **366***a*-**366***n*, **370** to **371**, and/or **375** to **376**) the chassis **100** does not impose any electrical limitations on those communications. Further, the number and spacing of the connectors is based merely on the configuration of the power distribution board **310** and the third networking modules **210** making it possible for the chassis **100** to use first networking modules **140***a*-**140***n* and the second networking module **150** of varying widths. Thus, the chassis **100** is usable for multiple generations of networking configurations.

Also inserted at the rear of the chassis **100** are the one or more fan trays **240** as further described with respect to FIG. **2**. As noted in FIG. **2** and further emphasized here, the one or more fan trays **240** optionally extend beyond the back of the chassis **100**. Each of the one or more fan trays **240** includes one or more fan modules **245**. As shown in FIG. **3**, each of the one or more fan modules **245** can include a first fan **380** and an optional second fan **385**. The use of both the first fan **380** and the second fan **385** can serve multiple purposes. The presence of the optional second fan **385** can provide for more air flow through the chassis **100** and thus better cooling capability. Additionally, the second fan **385** can provide redundancy in case of failure of either the first fan **380** or the second fan **385**. The chassis **100** also further includes one or more optional third fans **390** located near the mid-plane **190** of the chassis **100**. The one or more third fans **390** can help direct air flow from the front portion of the chassis **100** toward the rear portion of the chassis **100**. The one or more fan trays **240** and the one or more third fans **390** are typically mounted above a corresponding one of the one or more third networking modules **210**.

The chassis **100** may also include one or more baffles **395** to help direct air flow across a surface of each of the one or more third networking modules **210**. In combination with ventilation holes located on the front of the one or more first networking modules **140***a*-**140***n* and the second networking module **150** (as discussed below), air flow can typically be directed from the front **301** of the chassis **100** to the rear **302** of the chassis **100**. The general direction of air flow is depicted in FIG. **3** using dashed arrows. This configuration is consistent with data center practice of providing cooling air flow from the front of equipment toward the rear of equipment.

As discussed above and further emphasized here, FIG. **3** is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. According to some embodiments, the power distribution board **310** may further include one or more auxiliary connectors for coupling the one or more auxiliary power supply modules **135***a*-**135***d* to the power distribution board **310**.

FIG. **4** shows a simplified frontal diagram of the mid-plane **190** of the chassis **100** according to some embodiments of the present invention. As shown in FIG. **4**, at the mid-plane **190** of the chassis **100** various connection mechanisms are provided for distributing power to the one or more first networking modules **140**a-**140**n, the second networking module **150**, and the one or more third networking modules **210** and for interconnecting the one or more first networking modules **140**a-**140**n and the second networking module **150** to the one or more third networking modules **210**. At the upper portion of the chassis **100**, the power distribution board **310** provides power connections between the one or more first power supply modules **120**a-**120**d and the one or more first networking modules **140**a-**140**n and the second networking module **150**. The one or more power module connectors **321**a-**321**d can be mounted on the power distribution board **310**.

FIG. **4** also depicts that the power distribution board **310** extends below a first region **410** corresponding to the one or more first power supply modules **120**a-**120**d and into a second region **420** corresponding to the one or more first network modules **140**a-**140**d and the second network module **150**. The one or more third power distribution connectors **331**a-**331**n and the one or more optional fourth power distribution connectors **341**a-**341**n can be mounted on the power distribution board **310** in the second region **420**. Additionally, the seventh power distribution connector **351** and the eighth power distribution connector **356** can be mounted on the power distribution board **310** in the second region **420**.

Also shown in FIG. **4** is the array of third communication connectors **361**a-**361**n and second communication connectors **366**a-**366**n. Each of the third communication connectors **361**a-**361**n can be mounted on the front of a first one of the third networking modules **210**. Each of the fourth communication connectors **366**a-**366**n can be mounted on the front of a second one of the third networking modules **210**. Also shown are the seventh communication connector **371** and the eighth communication connector **376** mounted on the front of the first one of the third networking modules **210** and the front of the second one of the third networking modules **210**, respectively. Further, the number and spacing of the power distribution and communication connectors (e.g., the connectors **331**a-**331**n, **351**, **341**a-**341**a, **356**, **361**a-**361**n, **371**, **366**a-**366**n, and/or **376**) can be based merely on the configuration of the power distribution board **310** and the third networking modules **210** making it possible for the chassis **100** to use first networking modules **140**a-**140**n and the second networking module **150** of varying widths. Thus, the chassis **100** is usable for multiple generations of networking configurations.

Although not depicted in FIG. **3**, FIG. **4** also shows one or more interconnect boards **430**. Each of the one or more interconnect boards **430** can be configured to distribute power from the power distribution board **310** to the first one of the third networking modules **210** and the second one of the third networking modules **210** and/or to provide one or more communication paths between the first one of the third networking modules **210** and the second one of the third networking modules **210**. Located on the rear face of the one or more interconnect boards **430** are one or more connectors **440** that can be configured to receive corresponding connectors mounted at the front of the first one of the second networking modules **210** and the second one of the third networking modules **210**. In some embodiments, the one or more interconnect boards **430** may be extensions to the power distribution board **310**. In other embodiments, the one or more interconnect boards **430** may be connected to either the front or the rear of the power distribution board **310** using corresponding connectors.

FIG. **5** shows a simplified diagram of a first networking module **500** according to some embodiments of the present invention. In some embodiments, the first networking module **500** is representative of any one of the one or more first networking modules **140**a-**140**n. As shown in FIG. **5**, the first networking module **500** can typically be enclosed on five sides by a rigid or semi-rigid first networking module housing **510**. The first networking module housing **510** may enclose the front, top, bottom, and two sides of the first networking module **500** with the rear being left open to allow connections to a corresponding one of the one or more first power distribution connectors **330**a-**330**n, a corresponding one of the one or more second power distribution connectors **340**a-**340**n, a corresponding one of the one or more first communication connectors **360**a-**360**n, and a corresponding one of the one or more second communication connectors **365**a-**365**n. In some embodiments, the corresponding one of the one or more second power distribution connectors **340**a-**340**n may be optional.

The first networking module housing **510** typically includes a metal. The metal includes one or more selected from a group consisting of sheet metal, aluminum, steel, and the like. One or more electromagnetic interference (EMI) gaskets **520** can be mounted to the outside of the first networking module housing **510**. The one or more EMI gaskets **520** can be configured to provide additional EMI shielding to the gaps between the first networking module **500** and adjacent modules or the chassis frame **110**. One or more optional module alignment elements **530** can also be mounted to the outside of the first networking module housing **510**. The one or more module alignment elements **530** can be configured to provide keying so that the first networking module **500** may only be installed into the chassis **100** with a proper positioning and orientation.

As further shown in FIG. **5**, the front of the first networking module **500** can include an array of network connectors **540**. The array of network connectors **540** can be selected based on the number and type of network connections that are desired for connecting to external devices. The first networking module housing **510** may further include an array of ventilation holes **550** on its front face. The ventilation holes **550** permit the flow of air into the chassis **100** and across the interior of the first networking module **500**.

FIG. **6** shows a simplified diagram of the second networking module **150** according to some embodiments of the present invention. As shown in FIG. **6**, the second networking module **150** can typically be enclosed on five sides by a rigid or semi-rigid second networking module housing **610**. The second networking module housing **610** may enclose the front, top, bottom, and two sides of the second networking module **150** with the rear being left open to allow connections to the fifth power distribution connector **350**, the sixth power distribution connector **355**, the fifth communication connector **370**, and the sixth communication connector **375**. In some embodiments, the fourth power distribution connector **355** may be optional.

The second networking module housing **610** typically includes a metal. The metal includes one or more selected from a group consisting of sheet metal, aluminum, steel, and the like. One or more EMI gaskets **620** can be mounted to the outside of the second networking module housing **610**. The one or more EMI gaskets **620** can be configured to provide additional EMI shielding to the gaps between the second networking module **150** and adjacent modules or the chassis frame **110**. One or more optional module alignment elements **630** can also be mounted to the outside of the second networking module housing **610**. The one or more module alignment elements **630** can be configured to provide keying so that the second networking module **150** can only be installed into the chassis **100** with a proper positioning and orientation. The second networking module **150** may further include one or more mounting flanges **660**. The mounting flanges **660** can typically include a mounting hole **665**. The one or more mounting flanges **660** and their corresponding mounting holes **665** may be used to affix the second network module **150** to the frame **110** as further described above with respect to FIG. **1**.

As further shown in FIG. **6**, the front of the second networking module **150** can include an array of network connectors **640**. The array of network connectors **640** can be selected based on the number and type of network connections that are desired for connecting external devices. The second networking module housing **610** may further include an optional array of ventilation holes **650** on its front face. The ventilation holes **650** permit the flow of air into the chassis **100** and across the interior of the second networking module **150**.

FIG. **7** shows a simplified front view diagram of the frame **110** according to some embodiments of the present invention. As shown in FIG. **7**, the frame **110** can divide the interior of the chassis **100** into several regions. The frame **110** can typically include a metal. The metal includes one or more selected from a group consisting of sheet metal, aluminum, steel, and the like. Because the second networking module **150**, the one or more fan trays **240** and/or the one or more third networking modules **210** can be affixed to the frame **110** and configured to provide stability to the frame **110**, the frame **110** can use less material than a conventional chassis frame. This reduces the manufacturing cost of the frame **110** relative to a conventional chassis frame.

A power supply region **710** can typically be located at the top of the chassis **100** and can be configured to receive one or more first power supply modules **120***a*-**120***d*. The frame **110** in the power supply region **710** may also include one or more power supply guides **720**. Each of the one or more power supply guides **720** can be configured to aid in the positioning and alignment of the one or more first power supply modules **120***a*-**120***d*. In some embodiments, the one or more power supply guides **720** may be positioned between each of the one or more first power supply modules **120***a*-**120***d*. In some embodiments, the one or more power supply guides **720** may be positioned to align with one or more alignment elements located on the exterior of the one or more first power supply modules **120***a*-**120***d*.

FIG. **7** also shows a networking module region **730** in the frame **110** that can located below the power supply region **710**. The networking module region **730** can be configured to receive the one or more first networking modules **140***a*-**140***n* and the second networking module **150**. The frame **110** in the networking module region **730** may also include one or more networking module guides **740**. Each of the one or more networking module guides **740** can be configured to aid in the positioning and alignment of the one or more first networking modules **140***a*-**140***n* and optionally the second networking module **150**. In some embodiments, the one or more networking module guides **740** may be positioned between each of the one or more first networking modules **140***a*-**140***n* and optionally between the second networking module **150** and the adjacent first networking modules **140***a*-**140***n*. In some embodiments, the one or more networking module guides **740** may be positioned to align with one or more alignment elements **530** located on the exterior of the respective first networking module housing **510**. In some embodiments, the one or more networking module guides **740** may be optionally positioned to align with one or more alignment elements **630** located on the exterior of the second networking module housing **610**.

Also shown in FIG. **7** are one or more mounting tabs **750**. Each of the one or more mounting tabs **750** can include a mounting hole **760**. The one or more mounting tabs **750** and their corresponding mounting holes **760** can be configured to align with the one or more mounting flanges **660** and corresponding mounting holes **665** of the second networking module as further described with respect to FIG. **6**. The second networking module **150** may be affixed to the frame **110** using one or more fasteners in combination with the one or more mounting tabs **750** and the one or more mounting flanges **660** as further described with respect to FIG. **1**.

As discussed above and further emphasized here, FIG. **7** is merely an example, which should not unduly limit the scope of the claims. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. According to some embodiments, the frame **110** may also include rack mounting flanges around the outside front edges of the frame **110** and which can be configured to mount the chassis **100** to an equipment rack.

Although illustrative embodiments have been shown and described, a wide range of modification, change and substitution is contemplated in the foregoing disclosure and in some instances, some features of the embodiments may be employed without a corresponding use of other features. One of ordinary skill in the art would recognize many variations, alternatives, and modifications. Thus, the scope of the invention should be limited only by the following claims, and it is appropriate that the claims be construed broadly and in a manner consistent with the scope of the embodiments disclosed herein.

What is claimed is:

1. An electrical equipment chassis, the chassis comprising:

a frame open to a first side of the chassis and a second side of the chassis opposite the first side;

a first region being open to the first side of the chassis, and configured to receive one or more first networking modules oriented with a first orientation;

a second region being open to the second side of the chassis and configured to receive one or more fan trays and one or more second networking modules, the one or more second networking modules being oriented with a second orientation orthogonal to the first orientation; and

a power distribution board located near a mid-plane of the chassis and including one or more power connectors for coupling the one or more first networking modules to power being distributed on the power distribution board;

wherein:

the power distribution board only partially separates the first region from the second region; and

the chassis is sufficiently open to permit air flow from the first side to the second side.

2. The chassis of claim **1** wherein each of the one or more first networking modules is coupled to each of the second networking modules near the mid-plane of the chassis using one or more connectors.

3. The chassis of claim **1** wherein at least one of the first networking modules, the one or more fan trays, or the one or more second networking modules are configured to be affixed to the frame.

4. The chassis of claim **1** wherein the one or more first networking modules includes one or more line cards or one or more service modules.

5. The chassis of claim **1** wherein the one or more second networking modules include one or more route processing modules.

6. The chassis of claim **1** wherein the first region is further configured to receive a third networking module oriented with the first orientation, the third networking module being coupled to each of the second networking modules near the mid-plane of the chassis using one or more connectors.

7. The chassis of claim **6** wherein the third networking module includes an uplink module.

8. The chassis of claim **6** wherein the third networking module adds stability to the frame.

9. The chassis of claim **1**, further comprising a third region configured to receive one or more power supply modules for supplying power to the chassis and the power distribution board.

10. The chassis of claim **9** wherein the third region is adjacent to the first region and is open to the first side.

11. The chassis of claim **1**, further comprising an auxiliary power shelf configured to receive one or more auxiliary power modules.

12. The chassis of claim **1** wherein the one or more fan trays are configured to extend beyond the second side of the chassis.

13. The chassis of claim **1**, further comprising one or more additional fans located near the mid-plane of the chassis.

14. The chassis of claim **1**, further comprising one or more air baffles.

15. The chassis of claim **1** wherein at least one of the one or more first networking modules includes an electromagnetic interference gasket.

16. The chassis of claim **1** wherein at least one of the one or more first networking modules includes an alignment element.

17. The chassis of claim **1** wherein at least one of the one or more first networking modules includes an array of ventilation holes open to the first side of the chassis.

18. The chassis of claim **1** wherein at least one of the first networking modules or the one or more fan trays adds stability to the frame.

19. The chassis of claim **1** wherein the one or more fan trays each includes one or more fans.

20. An information handling system comprising:

one or more electrical equipment chassis, each chassis comprising:

a frame open to a first side of the chassis and a second side of the chassis opposite the first side;

a first region being open to the first side of the chassis, and configured to receive one or more first networking modules oriented with a first orientation;

a second region being open to the second side of the chassis and configured to receive one or more fan trays and one or more second networking modules, the one or more second networking modules being oriented with a second orientation orthogonal to the first orientation; and

a power distribution board located near a mid-plane of the chassis and including one or more power connectors for coupling the one or more first networking modules to power being distributed on the power distribution board;

wherein:

the power distribution board only partially separates the first region from the second region; and

the chassis is sufficiently open to permit air flow from the first side to the second side.

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